Space Weather Technical Forecast

Issued on Sunday 27 October 2024 at 13:26 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: S2 Moderate Radiation Storm ongoing. CME arrival likely early day 2 (28 Oct) with G1-G2 Minor to Moderate storms possible. Further M-class flares expected with chance of X-class flares.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Moderate with peak flare M2.8 at 26/1206 UTC from the northeast limb, alongside some ongoing contribution form the fading long duration X1.9 flare from AR3872/73 earlier in the day. There are thirteen regions on the disc, with the most complex AR3872, due to a small delta spot on the northern portion of its main spot, and some ongoing slight growth. This is one of three interconnected regions in the southeast disc, AR3869/72/73 with a history of significant flaring. Also on the southeast disc, AR3876 has seen the most notable growth with the emergence of intermediate spots and ongoing penumbra development. The other main region of note is likely the new region on the northeast limb, however this is hard to assess given its current location

No Earth-directed CMEs were observed in this period.

Solar Wind / Geomagnetic Activity: A glancing CME arrival was observed, likely from the X3.3 flare on 24 Oct. Solar winds, observed by ACE at L1, rose suddenly from background to become slightly elevated from 26/1535 UTC, then persisted 420-470km/s. Density was at or near average. Interplanetary Magnetic Field (IMF), Bt, also rose from Moderate levels (10-13nT) to become Strong after 26/1535 UTC, peaking at 27nT around 26/1900 UTC. The IMF then eased to be Moderate 8-10nT from 27/0900 UTC. The north-south component was strong, and varied turbulently between +/- 20nT until around 27/0000 UTC, and then became Weak to Moderate and mainly positive (northward). Phi angle remained negative (towards the Sun), perhaps indicating some influence of CH84/- fast wind. Geomagnetic activity was Quiet to Unsettled (Kp1-3) with an Active spell (Kp4) 26/1800-2400 UTC.

Energetic Particles / Solar Radiation: High energy proton flux observed by GOES18 rose gradually through the period, cross the S1 Minor Storm level just after 26/1800 UTC, and the S2 Moderate storm level just after 27/0830 UTC. This peaked 169 pfu at 27/1140 UTC, but continues to slowly rise. This is likely due to the protons swept up ahead of the potential CME arrival early on 28 Oct. High energy electron flux (greater than 2MeV) observed by GOES16 was Background to Moderate. The associated 24-hour fluence was well below the Active threshold, with 3.31e6 integrated flux observed at 27/0000UTC.

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Four-Day Space Weather Forecast Summary

Solar Activity: Moderate to High activity is expected, with further M-class flares expected and a chance of isolated X-class flares.

Solar Wind / Geomagnetic Activity: A CME arrival is likely, associated with the X1.8 flare on 26 Oct. This is forecast to arrive early on day 2 (28 Oct), but with a wide uncertainty for the expected arrival time. This is most likely to be a glancing impact, however there is a chance of G1-G2 Minor to Moderate storms. Otherwise slightly elevated solar winds may ease a little on day 1 (27 Oct). Any CME influence on day 2 is then likely to continue into day 3 (29 Oct), perhaps further enhanced by the weak fast wind from CH85, before easing. Mainly Quiet to Unsettled geomagnetic activity is likely, however the CME arrival gives the chance of a spell of G1-G2 Minor to Moderate storms, most likely day 2 (28 Oct).

Energetic Particles / Solar Radiation: The high energy proton flux at GOES-18 is currently at S2 Moderate Radiation Storm, and is likely to continue seeing a rising trend, ahead of the CME arrival early on day 2 (27 Oct). A rapid decay in the observed flux is then likely after the CME arrival, however further flares bring the potential for further enhancement. This includes a slight chance of reaching S3 Strong Storm. The high energy electron flux is expected to persist at mainly background, but may see a rising trend later in the period. However the associated fluence is forecast to persist below Active.

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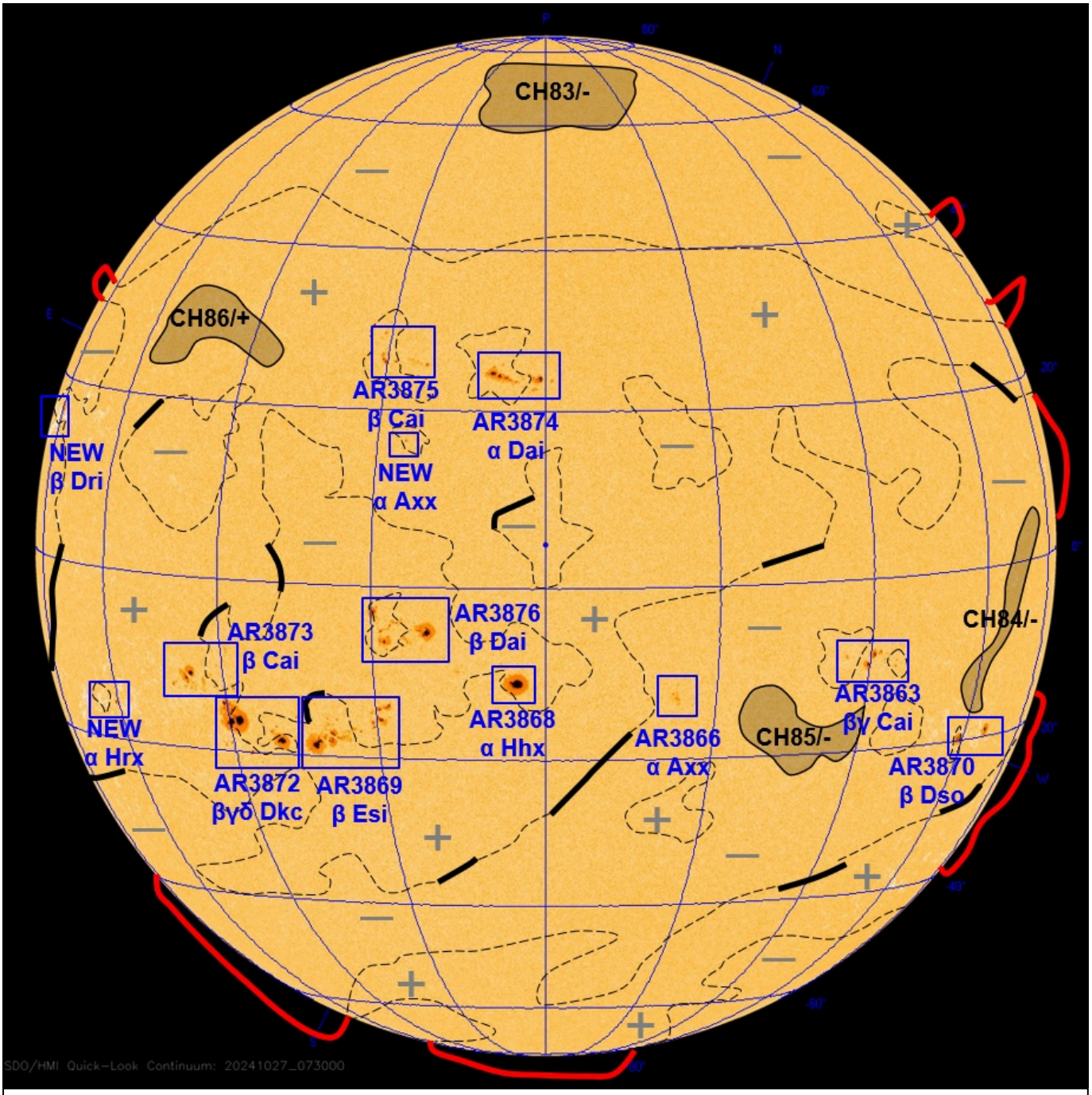
Figure 1: Solar Synoptic Map 27/0800 UTC



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Figure 2: L1 (ACE) observed solar winds, showing weak CME arrival

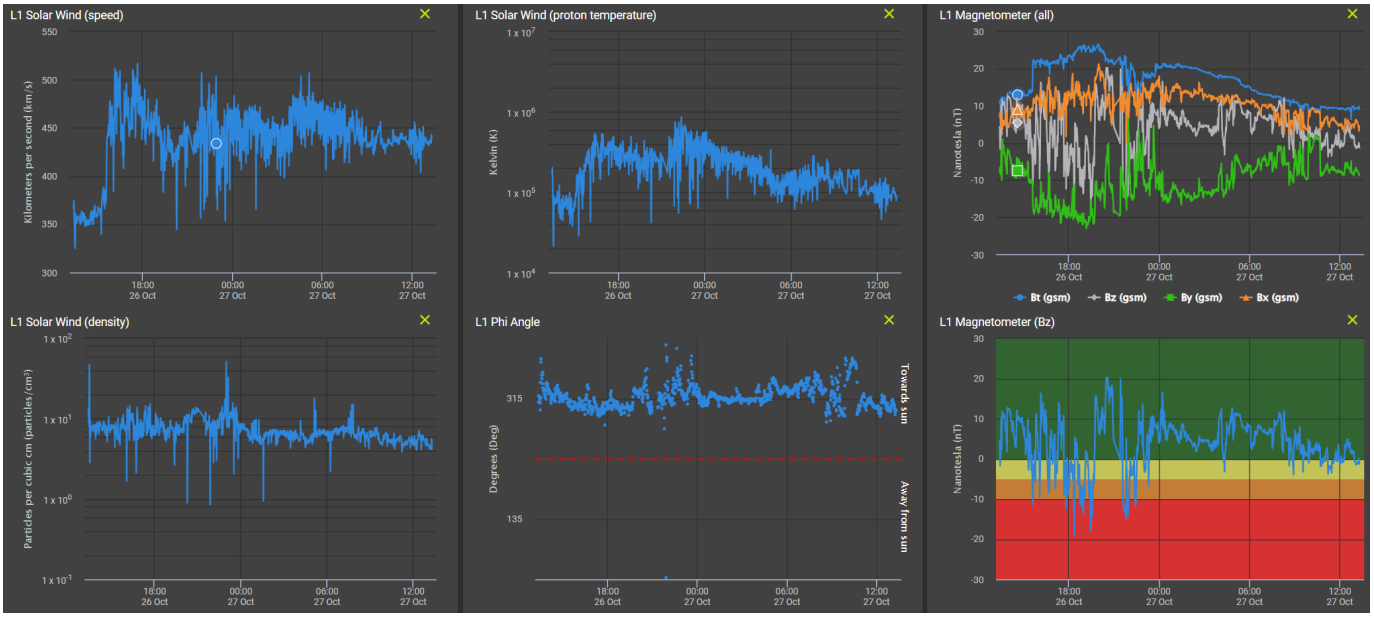
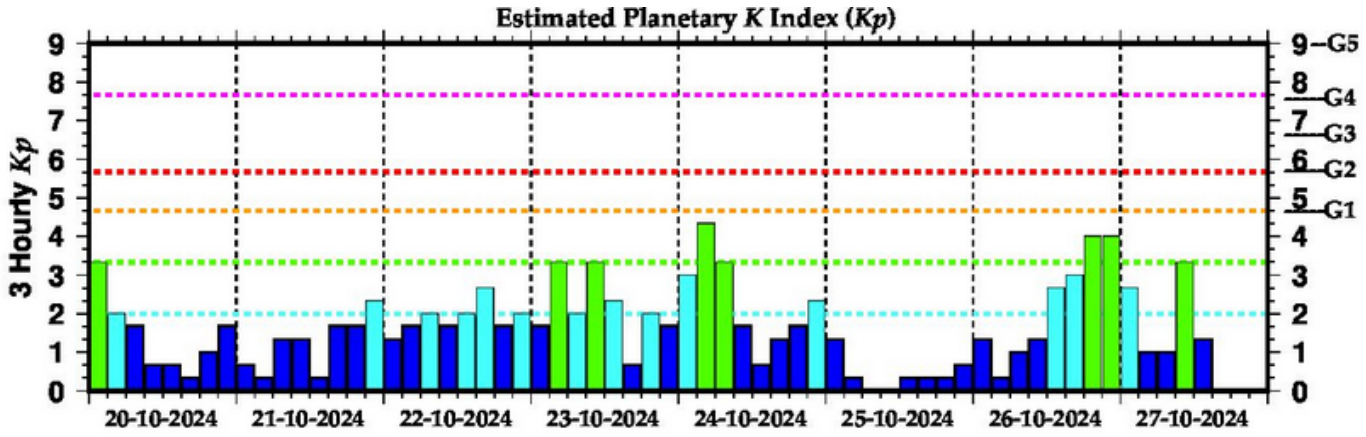


Figure 3: BGS Geomagnetic Activity



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Geomagnetic Storms

The geomagnetic forecast has some significant uncertainty due to the low confidence influence of the CME from the X1.8 flare on 26 Oct. This was a notable and relatively fast CME, but has the bulk of its material passing south and behind (east of) Earth. However, coronagraph imagery from SOHO shows a notable shock extending further west than the previous X3.3 CME, which was observed weakly glancing Earth on 26 Oct. Furthermore energetic protons have been showing the 'snow-plough' effect of an incoming CME, gradually building through the last 24 hours. Confidence for the timing and extent of any Earth-impact is reduced however, by MOSWOC Enlil having a poor representation of the the background winds, currently too fast by around 100km/s, and also the non-conical shape of the CME in analysis. This increases the error on modelled arrival of the CME edge, which is the portion that is most likely to glance Earth.

The most likely scenario is for a glancing impact early on day 2 (27 Oct), with a chance of G1-G2 Minor to Moderate storms. An earlier arrival remains possible, late on day 1 (26 Oct), and if Earth sees more of the CME then an isolated G3 Strong storm cannot be ruled out. However, it has also not been completely ruled out that the majority of the CME misses Earth, and only a very slight glancing impact is observed.

Ongoing influence of the CME is likely to continue into day 3 (29 Oct), along with any weak connection to CH85/- , with further Active to G1 minor storm intervals possible, however winds will likely to be easing to be slightly elevated, perhaps background by the end of the period. Aside from the CME arrival, mainly Quiet to Unsettled geomagnetic conditions are expected. However, any further notable flares and associated CMEs may change this.

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	20	50	20	5
Strong	G3	No	5	15	1	1
Severe	G4	No	2	2	1	1
Extreme	G5	No	1	1	1	1

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Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R⊙ (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed (km/s)	Estimated Arrival Time (UTC)	Comments
2024-10-26 09:40	Partial	X1.8 flare	SE	1493	28/0500 UTC	Moderate confidence in Earth-directed shock. Arrival +/- 8hrs

Figure 4: MOSWOC Enlil showing bulk of CME to south and east of Earth, with glancing impact. This is delayed in the forecast due to Enlil winds being too fast and likely differences due to analysis shape.

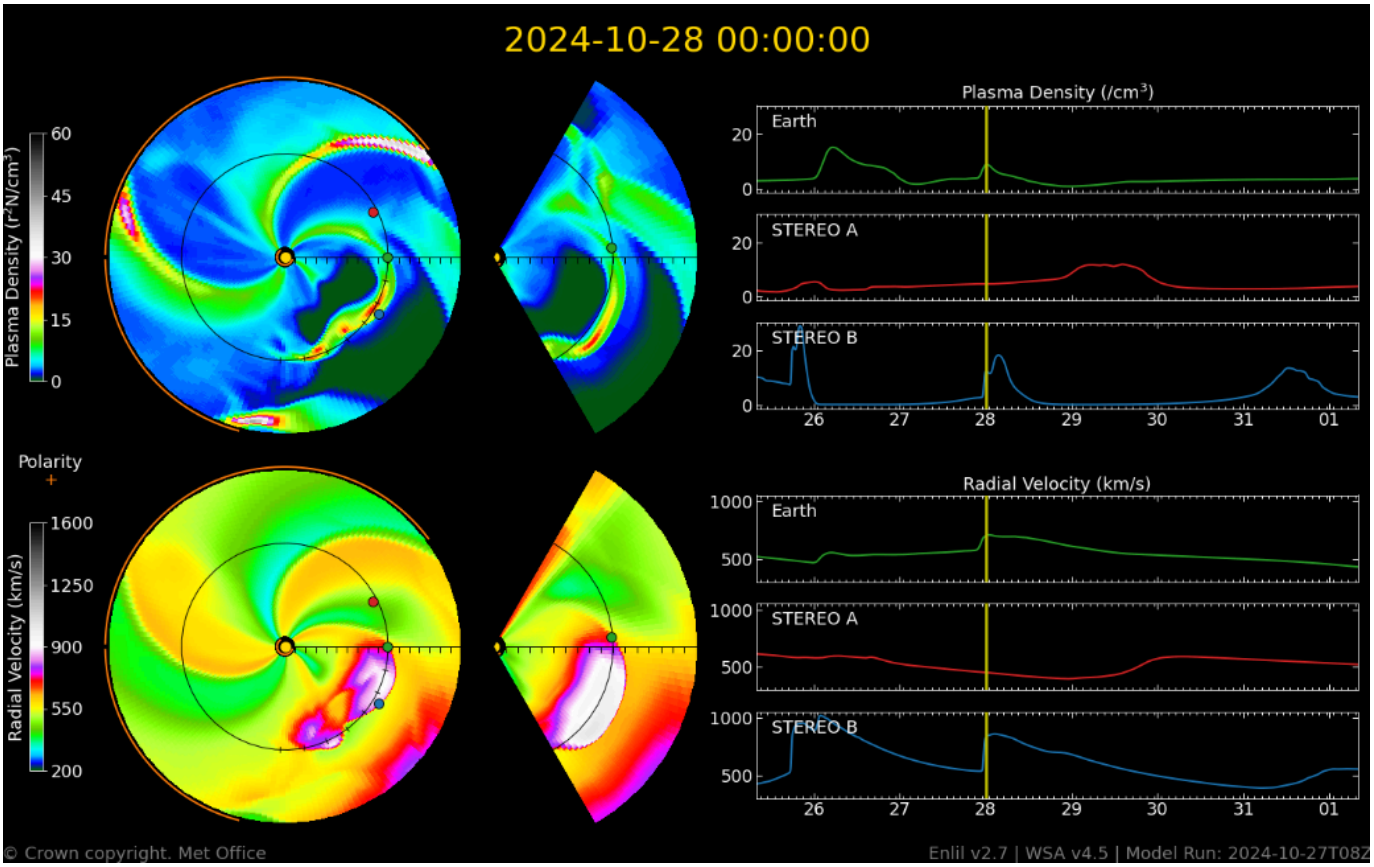

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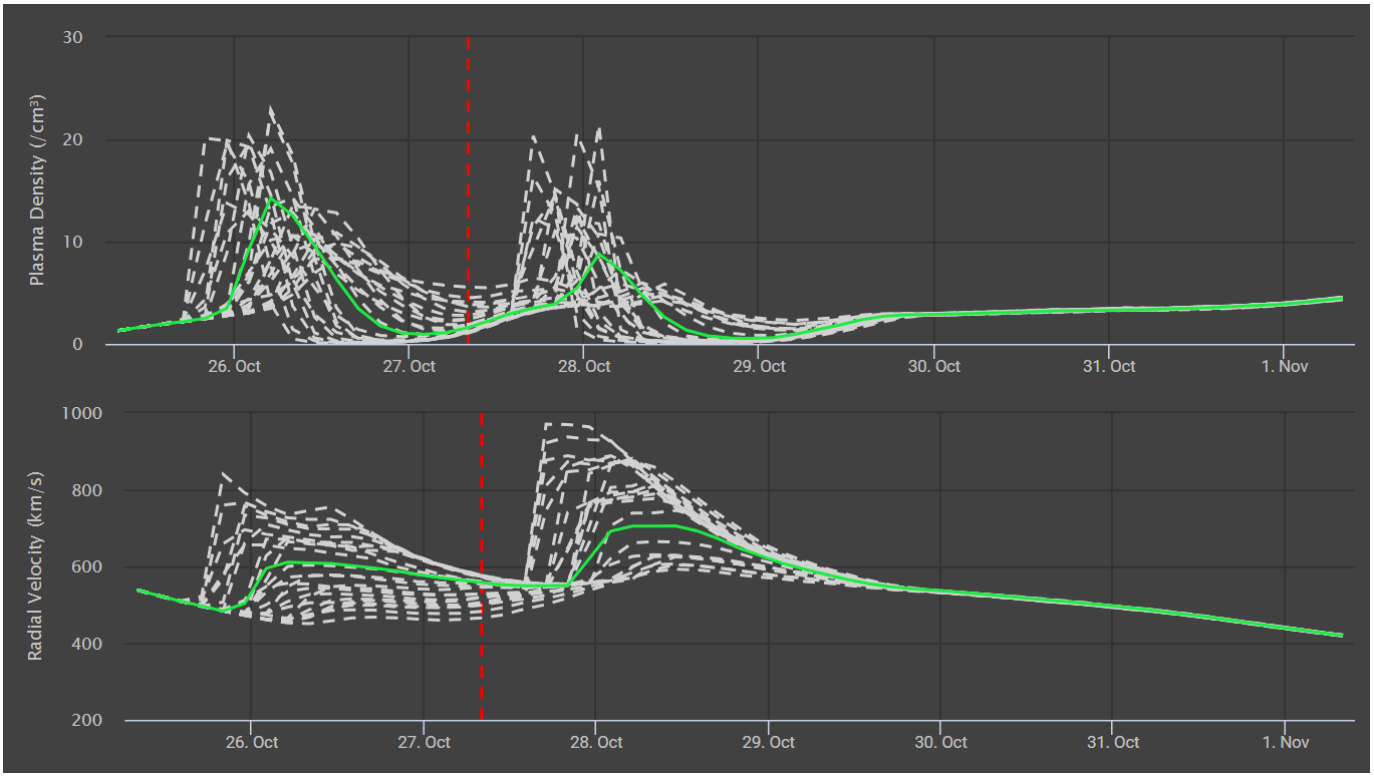
Figure 5: Ensemble, which explores the uncertainty of the CME analysis. All arrivals are considered likely 6 hours too early, due to the modelled background winds being too fast (as these are not varied in the ensemble)



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Radio Blackouts - X-Ray Flares

Moderate to High activity is expected.

There are thirteen sunspot regions currently on the disc, ten of which are numbered. The most complex of these is AR3872, which is the central component of broad complex of regions across the southeast which includes AR3869 to the west and AR3873 to the east. This region has the largest main spot which includes a delta spot on its northern periphery, along with some slight growth in penumbral extent. The other regions of this complex have remained stable.

The most notable growth on the the disc has been in AR3876, to the northwest of this group, but still in the southeast quadrant. This has seen growth within its intermediate spots and an ongoing increase in penumbra extent, but currently remains a simple bipolar configuration. Growth was also observed in AR3874 in the north-centre disc, with the development of main leader spot, but also some spreading and simplification of the region to a typical bipolar configuration. The other spots on the disc are mostly simple, or smaller. However a new region moving onto the disc from over the northeast limb has some associated bright magnetic looping evident in SDO imagery, which suggests this may also be a relatively complex region. However this is currently impossible to accurately assess given its on limb location.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	Yes	80	80	80	80
Very Active	R3-R5 (X Class)	No	30	30	25	20

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Figure 6: GOES-16/18 X-ray flux

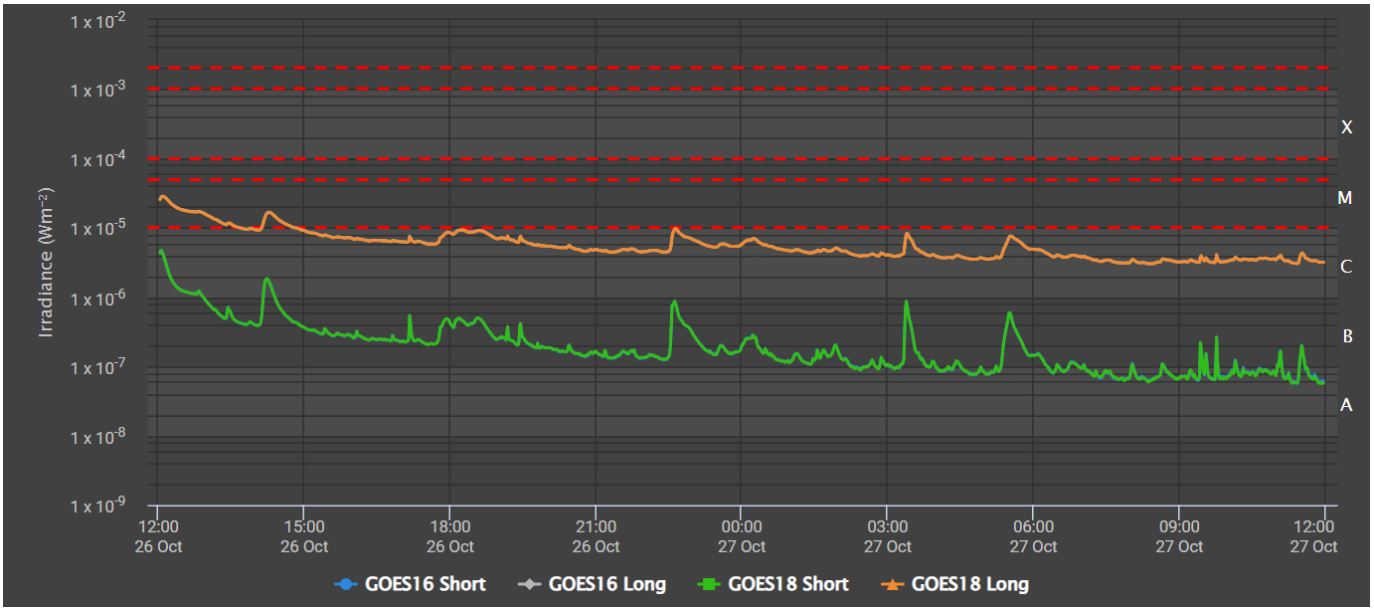
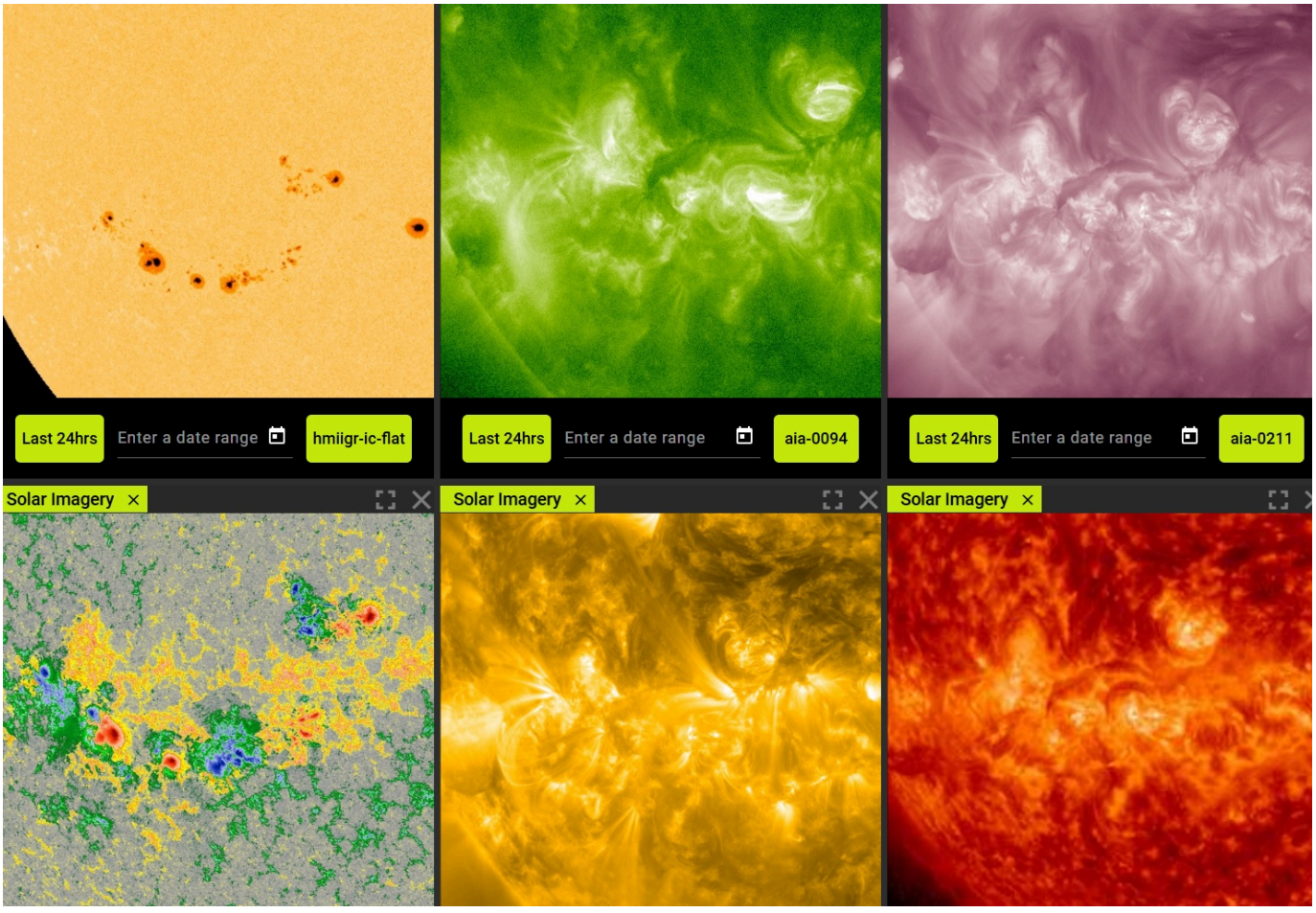


Figure 7: SDO imagery showing the SE cluster of sunspots, and AR3876 to the NW.



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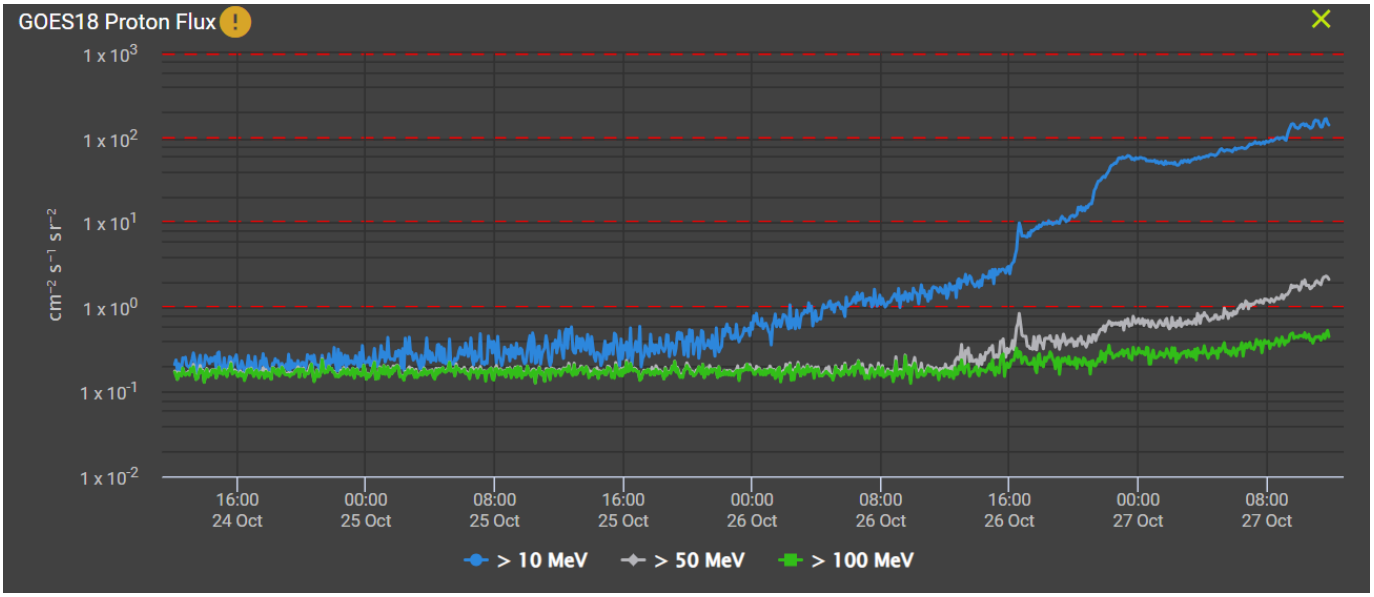
Solar Radiation Storms (High Energy Protons)

High energy proton flux at GOES-18 is currently at S2 Moderate Radiation storms, likely due to the 'snowplough' type affect of the approaching CME, after the X1.8 flare on 26 Oct. This flare, alongside the X3.3 flare on 24 Oct are both likely sources of these observed protons.

Observed protons are expected to continue slowly rising on day 1 (27 Oct), persisting at the S2 level until the arrival of the CME from the X1.8 flare, likely peaking just before this arrives, most likely early on day 2 (28 Oct). A fairly rapid decrease is then likely. However, given the potential for further notable flares from the region(s) that produced these proton storms, and with these regions moving into a more geoeffective location, the potential for further enhancement is maintained throughout. This includes a slight chance of reaching the S3 Strong Radiation Storm level.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	99	80	25	25
Very Active	**≥ S3 ***	No	10	10	10	10
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 8: GOES-18 proton flux over the last three days for >10MeV, >50MeV and >100MeV. The gradual increasing trend is likely due to a 'snow-plough' type effect as the 26 Oct CME approaches.



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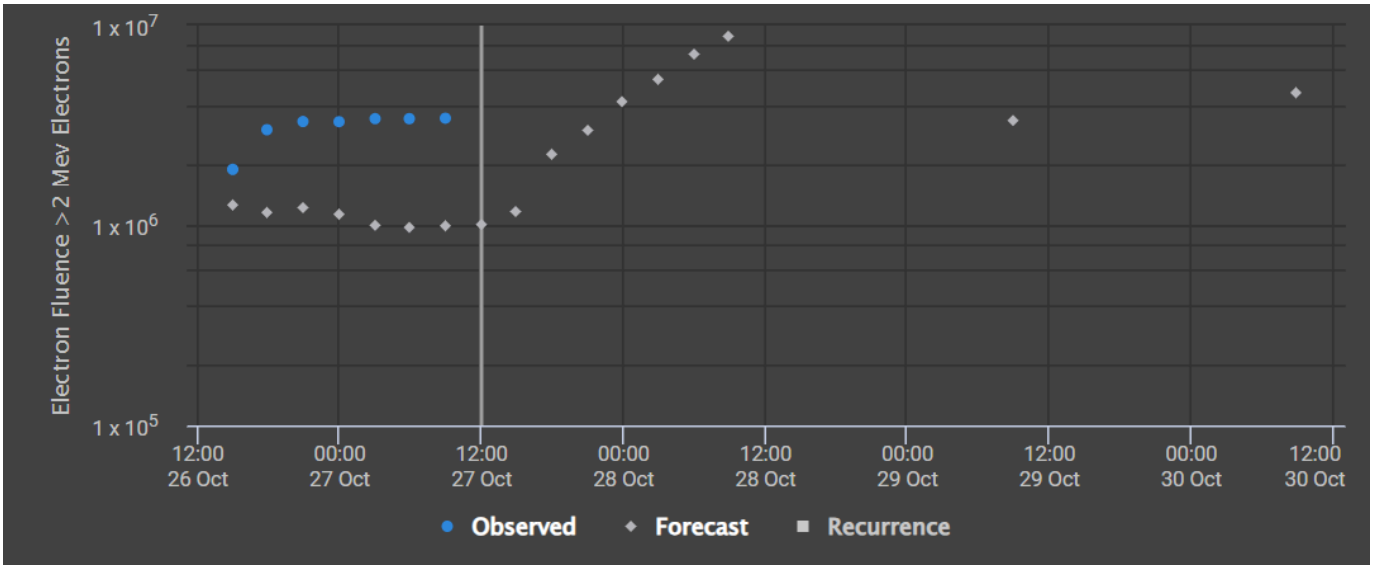
High Energy Electrons (≥ 2MeV)

High energy electron flux (greater than 2MeV) as observed by GOES16 is currently at Background levels, and is expected to persist mainly at this level, due to the ongoing CME influence and the further forecast CME arrival early on day 2 (28 Oct). As this influence recedes, there is a slight chance of the observed electron flux increasing at GOES, likely rising to Moderate with a slight chance of reaching High day 4 (30 Oct).

The associated 24-hour fluence is currently expected to remain well below Active throughout the period, with the MOSWOC REFM forecast though to be providing good guidance. However this guidance may become less useful, after the arrival of any CME on 28 Oct.

GEO Electron Environment	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1×10^{8}	No	1	1	1	5
Very Active	≥ 2 MeV ≥ 1×10^{9}	No	1	1	1	1

Figure 9: GOES-16 24hr >10 MeV Electron Fluence with REFM



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